

(19) World Intellectual Property Organization  
International Bureau



(43) International Publication Date  
9 August 2001 (09.08.2001)

PCT

(10) International Publication Number  
**WO 01/58218 A1**

(51) International Patent Classification<sup>7</sup>: **H05B 33/08**

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(21) International Application Number: **PCT/EP01/00116**

(22) International Filing Date: **8 January 2001 (08.01.2001)**

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(25) Filing Language: **English**

(81) Designated States (*national*): **CN, JP, KR, MX.**

(26) Publication Language: **English**

(84) Designated States (*regional*): European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR).

(30) Priority Data:  
00200370.5      3 February 2000 (03.02.2000)      EP

**Published:**

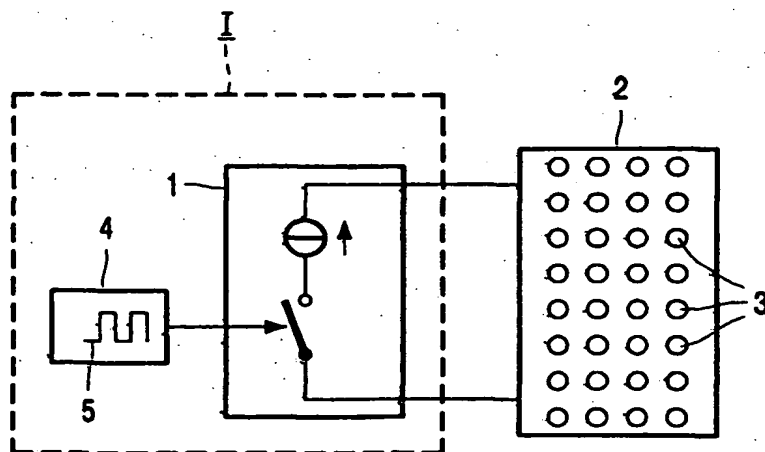
- with international search report
- before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments

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(54) Title: **SUPPLY ASSEMBLY FOR A LED LIGHTING MODULE**



(57) Abstract: A supply assembly for a LED lighting module, comprising a PWM controlled current source supply unit to which the LED lighting module can be connected and a burst control unit which is capable of switching the power supply unit on and off with a burst frequency (fburst) so as to control the mean light output. Preferably, the burst control unit is provided with a pulse duration modulator for controlling the pulse length (T pulse) during which the supply unit is operative.

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## Supply assembly for a LED lighting module

The invention relates to a supply assembly for a LED lighting module, comprising a supply unit to which the LED lighting module can be connected and a burst control unit which is capable of switching the power supply (the voltage or the current) to the LED lighting module on and off with a burst frequency so as to control the mean light output of the LED lighting module.

LED lighting modules are being used more and more to illuminate objects. They are also used as signal lighting, for example in traffic lights. The light output of a LED lighting module can be controlled in various well-known ways. One of said ways consists in controlling (dimming) the current intensity through the module. This has the drawback that at a current intensity below approximately 20% of the nominal current intensity, the relation between the current intensity and the light output becomes largely non-linear, and the efficiency of the module becomes far from optimal. Therefore, solutions have been sought which enable the light intensity to be controlled while the nominal current intensity through the module is maintained. US 5, 661, 645 describes a supply unit for a LED lighting module as described in the opening paragraph. In said document, the burst control unit is arranged between an output of a voltage source and the LED lighting module, so that the power supply to the module with a certain burst frequency can be switched on and off. The voltage source is continuously in the on-state, also when the power supply to the LED lighting module is cut off, which results in an unnecessary loss of energy.

It is an object of the invention to provide an efficient, reliable, inexpensive and simple supply assembly for a LED lighting module with an improved efficacy.

This is achieved in accordance with the invention in that the burst control unit is capable of switching the power supply unit on and off with the burst frequency. In this case, the supply unit is in the on-state only when current is actually being supplied, so that the generation of heat and energy losses are minimized, resulting in an improved efficacy of the system.

Preferably, the burst control unit comprises a pulse-duration modulator which is capable of controlling the length of the pulses during which the supply unit is in the on-state. This enables the mean light output to be controlled.

Preferably, the supply unit is a controlled constant-current source. This has the advantage that further measures in the LED module, such as the provision of additional resistors, are not necessary to control the electric current through the LEDs.

Preferably, the supply unit is a high-frequency switch mode power supply (smmps) which supplies a ripple DC current or a ripple DC voltage, said supply unit preferably comprising a half-bridge converter, a buck converter or a flyback converter. The pulse duration modulator can preferably switch the converter on and off with the burst frequency. In this way, the desired effect can be achieved very efficiently. In addition, preferably the ripple frequency of the converter is an integer multiple of the burst frequency, and the ripple DC voltage or ripple DC current can be synchronized with the burst control signal, resulting in a reduction of any stability problems and loss of energy in the system.

For the same reason, the burst frequency preferably is an integer multiple of the frequency (customarily 50 Hz or 60 Hz) of the voltage source, for example the mains voltage to which the supply assembly can be connected, and the burst control signal is synchronized with the mains voltage signal.

Preferably, the burst frequency lies in the range between 50 and 200 Hz or above 20 kHz; more preferably the burst frequency is 100 Hz (if the mains frequency is 50 Hz) or 120 Hz (if the mains frequency is 60 Hz). When use is made of a half-bridge converter, it is best if the burst frequency is chosen as low as possible in connection with switching losses. However, the frequency should preferably exceed the frequency that can be observed by the human eye (approximately 70 Hz), because at a lower frequency the flicker produced by the LEDs is noticeable, which is annoying. In addition, the frequency should preferably be outside the human range of hearing of 200 Hz to 20 kHz to preclude disturbing sound effects.

Preferably, the current supplied by the supply unit in the on-state to the LED lighting module is a constant current which has been chosen as a nominal current, and which results in an optimum light output of the LED lighting module, so that the supply unit can be optimized for the nominal current intensity, which has a favorable effect on the efficacy.

In a preferred embodiment, the burst control unit is coupled to a sensor which is capable of measuring the temperature and/or the light output of the LED lighting module, said burst control unit being capable of controlling the length of the pulses during which the supply unit is in the on-state in dependence upon the value measured by the sensor. By virtue thereof, the light output of the module can be stabilized under varying conditions. In a further

preferred embodiment, the duration of the pulses can be adjusted by a user. By virtue thereof, the light output of the module can be dimmed in accordance with the user's needs.

The supply assembly as herein disclosed is also suitable to operate a LED lighting module which forms part of a display unit, for instance a liquid crystal display (LCD).

These and other aspects of the invention will be apparent from and elucidated with reference to the embodiments described hereinafter.

In the drawings:

Fig. 1A diagrammatically shows a supply assembly to which a LED lighting module is connected.

Fig. 2 shows a graph wherein the current through the LED lighting module is shown as a function of time.

Fig. 3 shows a first detailed example of the system shown in Figure 1.

Fig. 4 shows a second detailed example of the system shown in Figure 1.

As shown in Fig. 1, a supply assembly I comprises a supply unit, preferably a controlled constant-current source 1, which supplies current to a LED lighting module 2. The LED lighting module 2, for instance as backlight for a LCD comprises a number of light-emitting diodes (LEDs) 3, which may be parallel-connected or series-connected. The figure diagrammatically shows that a burst control unit 4 is capable of switching the controlled constant-current source 1 on and off. For this purpose, the burst control unit 4 emits a burst control signal 5 which is composed of pulses having a duration  $T_{\text{pulse}}$  which switch on the controlled constant-current source 1 with a burst frequency  $f_{\text{burst}}$ , as shown in Figure 2. The burst frequency  $f_{\text{burst}}$  should exceed the frequency that can be observed by the human eye (approximately 70 Hz) because at a lower frequency the flicker produced by the LED lighting module would be very disturbing (cf the monitor of a display tube). However, the burst frequency  $f_{\text{burst}}$  should not exceed a certain value because this would lead to an unnecessary amount of switching losses and, in addition, might cause undesirable, audible background noises.

In this example, the controlled constant-current source 1 is a high-frequency switch mode power supply (smps) comprising a half-bridge converter, which half-bridge

converter can be switched on and off by the burst control unit. Other high-frequency converters, such as a buck converter, a flyback converter and other types of converters can also suitably be used as a controlled constant-current source. Such a known controlled constant-current source delivers direct current, the current intensity and/or the voltage of which can be controlled. The distinctive feature of such a controlled constant-current source is that the direct current is a ripple direct current, which means that the current intensity varies with a high ripple frequency between a minimum value 6 and a maximum value 7. The mean of this minimum value 6 and maximum value 7 is the mean direct-current intensity 8 of the controlled constant-current source 1. This current intensity 8 is preferably equal to the current chosen as the nominal current for the LED lighting module 2. The ripple signal of the controlled constant-current source 1 is preferably synchronized with the burst control signal in order to preclude additional switching losses.

Figure 2 shows the situation wherein the mean size of the current 9 through the LED lighting module 2 is set at 50% of the mean current 8 of the controlled constant-current source. This is achieved by setting the pulse duration  $T_{\text{pulse}}$  at 50% of the cycle length ( $f_{\text{burst}}$ ). By varying the pulse duration  $T_{\text{pulse}}$ , the mean size of the current 9 through the LED lighting module 2 can obtain any desired value between 0% and 100% of the nominal current delivered by the controlled constant-current source 1. To this end the burst control unit 4 is provided with a pulse duration modulator.

Figures 3 and 4 show preferred embodiments of a supply assembly I, the supply assembly I as shown in Figure 3 being connectable to an AC voltage source, such as the mains, and the supply assembly I as shown in Figure 4 being connectable to a DC voltage source, such as a battery. In common with Figure 1, the high-frequency switch mode power supply shown in Figures 3 and 4 comprises a controlled constant-current source (Switch mode current source) 1, the LED lighting module (LED MODULE) 2 and the burst control unit (Burst control) 4.

The burst control unit 4 may be connected to a dimming device (Dim interface) 14 which can be set by a user via a bus (Bus). The dimming device is capable of controlling the pulse duration (also referred to as pulse width)  $T_{\text{pulse}}$  of the burst control unit 4 by means of a voltage signal ( $V_{\text{dim}}$ ).

As the light output of LEDs is temperature-dependent, the LED lighting unit 2 may be provided with sensors which observe the temperature ( $TEMP\_OUT$ ) and/or the light output ( $OPT\_OUT$ ) of the LED lighting unit 2. The sensors can send a voltage signal ( $V_{TF}$  and  $V_{OF}$ , respectively) to the burst control unit 4, said voltage signals also being capable of

controlling the pulse duration  $T_{\text{pulse}}$ . By means of this feedback the light output of the LED lighting module 2 can be efficiently stabilized.

In accordance with Figure 3, the controlled constant-current source 1 is fed, in a manner which is known per se, by a filter/rectifier (Filter/rect.) 10 and a preconditioning device (Preconditioner) 11, which are connected to, for example, a grounded electric mains (110V/60Hz or 230V/50Hz) with terminals L, N and PE. In the case of low-power systems (< 25W), the preconditioning device can be replaced by a simple energy buffer. To preclude any problems regarding the stability of the preconditioning device, it is important to synchronize the burst control signal with the mains voltage signal by means of a synchronization signal (Sync). Auxiliary supply (Aux. supply) 15 provides the different parts of the system with the necessary low-voltage supply.

In accordance with Figure 4, the controlled constant-current source 1 is fed by a DC filter (Filter) 12, and optionally a DC/DC converter (DC-DC converter) 13, which are connected to a storage cell or a battery having terminals L and N.

## CLAIMS:

1. A supply assembly for a LED lighting module, comprising a supply unit to which the LED lighting module can be connected and a burst control unit which is capable of switching the power supply to the LED lighting module on and off with a burst frequency ( $f_{burst}$ ) so as to control the mean light output of the LED lighting module, characterized in that the burst control unit is capable of switching the supply unit on and off with the burst frequency ( $f_{burst}$ ).  
5
2. A supply assembly as claimed in claim 1, characterized in that the burst control unit comprises a pulse-duration modulator which is capable of controlling the length ( $T_{pulse}$ ) of the pulses during which the supply unit is in the on-state.  
10
3. A supply assembly as claimed in claim 1 or 2, characterized in that the supply unit is a controlled constant-current source.
- 15 4. A supply assembly as claimed in claim 1, 2 or 3, characterized in that the supply unit is a high-frequency switch mode power supply which supplies a ripple DC current or a ripple DC voltage.
5. A supply assembly as claimed in claim 4, characterized in that the pulse duration modulator can switch the converter on and off with the burst frequency ( $f_{burst}$ ).  
20
6. A supply assembly as claimed in claim 4 or 5, characterized in that the ripple frequency of the converter is an integer multiple of the burst frequency ( $f_{burst}$ ), and the ripple DC voltage or ripple DC current can be synchronized with the burst control signal.  
25
7. A supply assembly as claimed in any one of the preceding claims, characterized in that the burst frequency ( $f_{burst}$ ) is an integer multiple of the frequency of the mains voltage to which the supply assembly can be connected, and the burst control signal can be synchronized with the mains voltage signal.

8. A supply assembly as claimed in any one of the preceding claims, characterized in that the burst frequency (fburst) lies in the range between 50 and 200 Hz or above 20 kHz.

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9. A supply assembly as claimed in any one of the preceding claims, characterized in that the burst frequency (fburst) is 100 or 120 Hz.

10. A supply assembly as claimed in any one of the preceding claims, characterized in that the current (ILED) supplied by the supply unit in the on-state to the LED lighting module is a constant current which has been chosen as a nominal current, and which results in an optimum light output of the LED lighting module.

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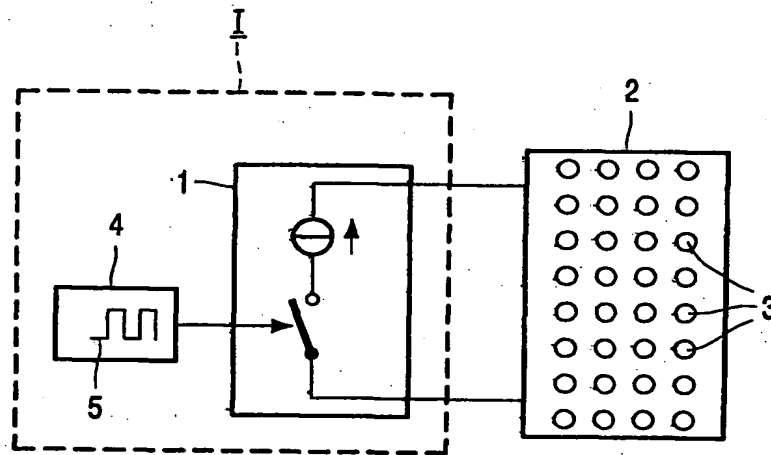


FIG. 1

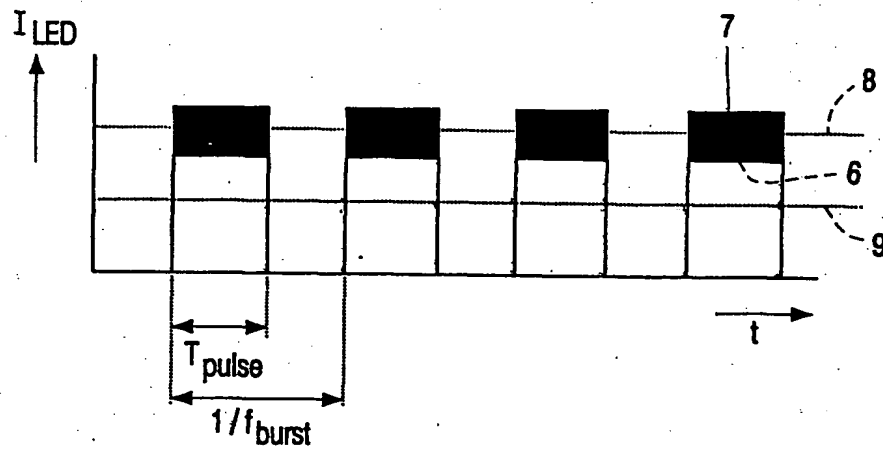
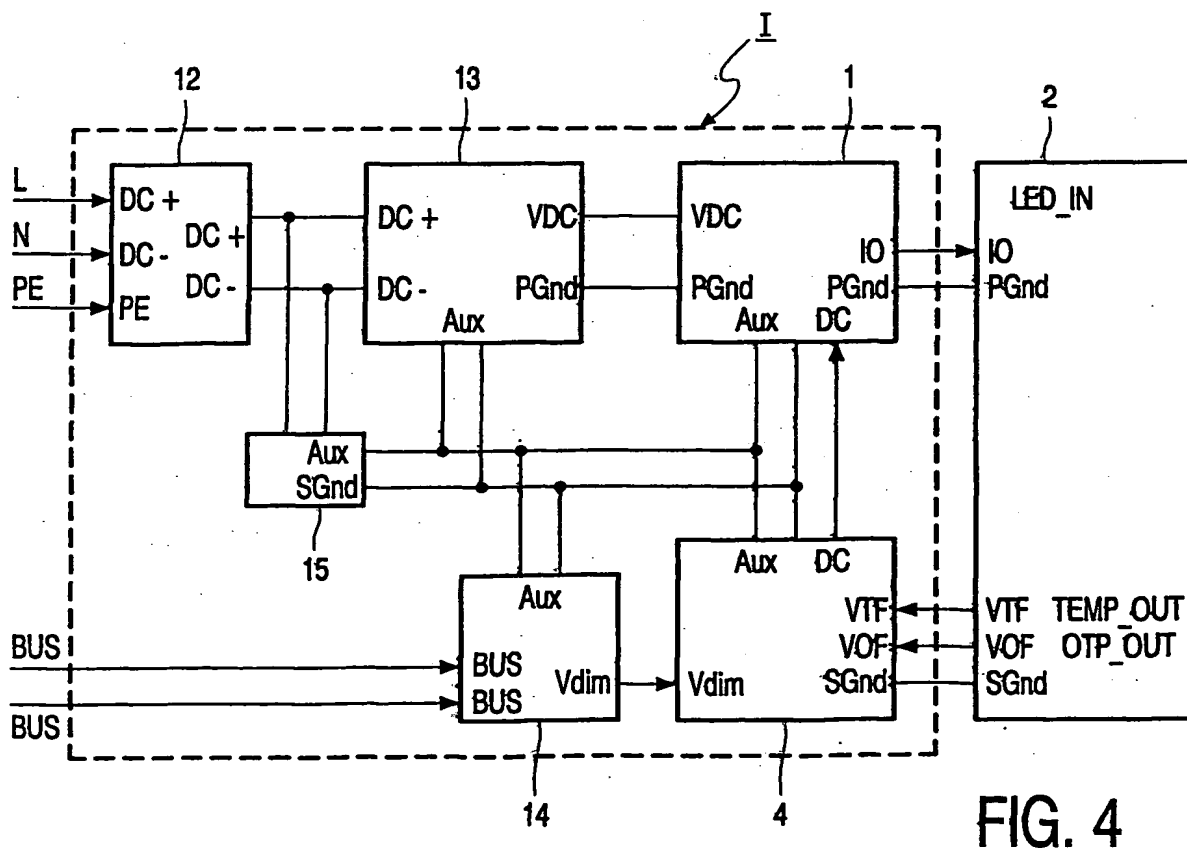
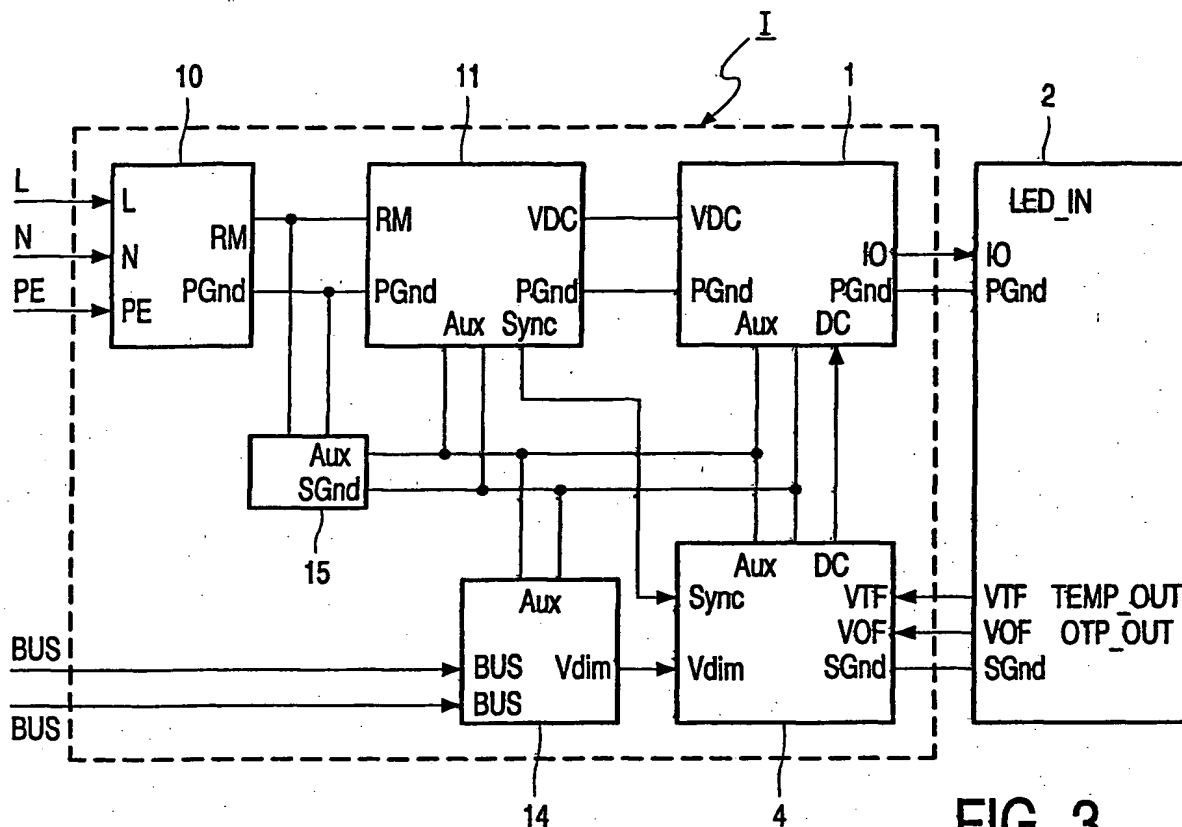


FIG. 2

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## INTERNATIONAL SEARCH REPORT

Int onal Application No

PCT/EP 01/00116

A. CLASSIFICATION OF SUBJECT MATTER  
IPC 7 H05B33/08

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 H05B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 912 568 A (KILEY DAVID A) 15 June 1999 (1999-06-15) abstract; figures column 2, line 13 - line 35 column 3, line 16 - line 57 column 4, line 37 - line 64 claims 1-4	1-6, 10
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A	EP 0 567 280 A (HUGHES AIRCRAFT CO) 27 October 1993 (1993-10-27) abstract; figures column 4, line 17 - line 33 claims 1,5	1-4

☐ Further documents are listed in the continuation of box C.

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Date of the actual completion of the international search

21 May 2001

Date of mailing of the international search report

31/05/2001

Name and mailing address of the ISA

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**INTERNATIONAL SEARCH REPORT**  
Information on patent family members

Int onal Application No  
**PCT/EP 01/00116**

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